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(54) Title: USE OF A CALCIUM POTASSIUM NITRATE SALT FOR THE MANUFACTURE OF A HEAT TRANSFER FLUID

(57) Abstract: The present invention relates to the use of a double salt of $\text{Ca}(\text{NO}_3)_2$ and KNO_3 for the manufacture of a melt, in particular a nitrate-based heat transfer fluid (HTF) and/or thermal energy storage fluid, for example in solar energy applications, such as in solar electrical power plant systems using a parabolic through, a central receiver or a linear Fresnel, which have both a low melting temperature and a high decomposition temperature, as well as to methods for the manufacture thereof. Using said double salt, a melt could be manufactured comprising at least NaNO_3 , KNO_3 and $\text{Ca}(\text{NO}_3)_2$, preferably, an eutectic ternary melt comprising $\text{Ca}(\text{NO}_3)_2$, NaNO_3 and KNO_3 in a weight ratio of about 42:15:43 with an operating temperature of about 131 °C to about 560 °C.

USE OF A CALCIUM POTASSIUM NITRATE SALT FOR THE MANUFACTURE OF A HEAT TRANSFER FLUID

FIELD OF THE INVENTION

5 The present invention relates to the use of a calcium potassium
nitrate salt for the manufacture of a melt, in particulate a nitrate-based heat
transfer fluid (HTF) and/or thermal energy storage fluid, for example in solar
energy applications, such as in solar electrical power plant systems using a
parabolic through, a central receiver or a linear Fresnel, which have both a
10 low melting temperature and a high decomposition temperature, as well as
to a method for the manufacture thereof.

BACKGROUND OF THE INVENTION

15 Concentrating solar power (CSP) uses mirrors to focus solar
energy to boil water and to make high pressure steam. The steam
subsequently drives a turbine and generator unit to generate electricity.
There is a need to bring CSP electricity cost down to the point of being
competitive with traditional fossil fuel-based electricity. An advanced low
melting point heat transfer fluid (HTF) with a high thermal stability is a key
20 technical advance necessary to reduce the cost of CSP electricity. Such a
material would enable higher temperature operation and increased efficiency
in converting solar energy to electricity. Increasing the maximum fluid output
temperature of current CSP plants from 390 °C to 500 °C would increase the
conversion efficiency of the Rankine power block, thereby reducing the
25 levelized energy cost by 2 cents/kWh. Achieving 500 °C operation would
also double the effectiveness of sensible heat thermal storage systems,
significantly reducing the capital cost of thermal storage (Justin W. Raade
and David Padowitz, *Development of Molten Salt Heat Transfer Fluid With
Low Melting Point and High Thermal Stability*, J. Sol. Energy Eng. 133,
30 031013 (2011)).

 Furthermore, an advanced low melting point heat transfer fluid
could also be used as a thermal energy storage fluids in solar energy

applications. Heat storage allows a solar thermal plant to produce electricity at night and on overcast days. This allows the use of solar power for continuous power generation as well as peak power generation, with the potential of displacing both coal- and natural gas-fired power plants.

5 Additionally, the utilization of the generator is higher which reduces cost.

Heat is transferred to a thermal storage medium in an insulated reservoir during the day, and withdrawn for power generation at night. The envisioned product should be cheap to produce, easy to make and easy to
10 handle.

A number of different solutions to the aforementioned problem has been proposed, one of them being the use of nitrate-based salts used as a melt (molten salt). Molten salts exhibit many desirable heat transfer qualities at high temperatures. They have high density, high heat capacity,
15 high thermal stability, and very low vapour pressure even at elevated temperatures. Their viscosity is low enough for sufficient pumpability at high temperatures, and many are compatible with common stainless steels. Salts of many varieties are currently available in large commercial quantities from several suppliers.

20 Most commonly, a binary salt based on NaNO_3 and KNO_3 and commonly known as Solar Salt, is used as heat transfer fluids and as thermal energy storage fluids. The Solar Salt consists of the eutectic mixture of 60 % NaNO_3 and 40 % of KNO_3 . NaNO_3 melts at 307 °C and KNO_3 melts at 337 °C. The mixture at its eutectic point exhibits a drastically
25 reduced melting point of 222 °C. This represents a melting point suppression of 85 °C from the lowest melting single component. It is produced as a double salt in solid (granular) form, for example as disclosed in US 4 430 241 (Fiorucci, 1984). Although the salt is very cheap and has a high thermal stability, a major drawback of this salt is its high melting temperature (220
30 °C).

Bradshaw et al. in Solar Energy Materials 21 (1990) 51-60 describe the use of ternary nitrate salts comprising nitrate salts of Na, Ca

and K, for solar thermal energy systems (see Table 1 therein). Adding $\text{Ca}(\text{NO}_3)_2$ to the Solar Salt showed to lower the melting temperature, which is an advantage as it lowers the risk of solidifying of the salt mixture in the system, blocking pumps, piping, etc..

5 As is commonly known, $\text{Ca}(\text{NO}_3)_2$ in its anhydrous form is a hygroscopic solid, forming the (liquid) tetrahydrate salt $\text{Ca}(\text{NO}_3)_2 \cdot 4\text{H}_2\text{O}$ with a melting point of about 43 °C. It is commercially available as a liquid solution or in solid particulate form, where it is mixed with ammonium nitrate to reduce its tendency to absorb water, in particulate water from the air. In
10 its particulate form, it is difficult to handle.

 From the disclosed melt compositions in Bradshaw et al. in Solar Energy Materials 21 (1990) 51-60, it can be concluded that the thermal stability decreases with increasing amounts of $\text{Ca}(\text{NO}_3)_2$. At amounts of 42 weight% of $\text{Ca}(\text{NO}_3)_2$, the decomposition temperature is about 500 °C and a
15 solid phase (CaCO_3) was visually detected. Similar research was conducted by the US Department of Energy and the Sandia National Laboratories and several reports are available on the internet (see e.g. Steven St. Laurent, Thermocline Thermal Storage Test for Large-scale Solar Thermal Power Plants), where a melt mixture is disclosed manufactured from melting
20 together 30 weight% of $\text{Ca}(\text{NO}_3)_2$, 24 weight% of NaNO_3 , and 46% of KNO_3 , all in solid form.

 Hitec XL (Coastal Chemical) is commercially available as an aqueous solution of a ternary nitrate salt mixture containing 59 weight% water, comprising $\text{Ca}(\text{NO}_3)_2$, NaNO_3 and KNO_3 , of which different
25 compositions have been reported. When the water is boiled off, the melt has a composition which has been reported to be 15 % NaNO_3 , 43 % KNO_3 and 42 % $\text{Ca}(\text{NO}_3)_2$ (Kelly et al., 2007), whereas Kearney et al (2003) quote 7 % NaNO_3 , 45 % KNO_3 and 48 % $\text{Ca}(\text{NO}_3)_2$. The eutectic mixture lies at a concentration ratio of 7% / 30 % / 63 % (ENEA, 2001). In practice, and
30 mainly for cost reasons, the exact eutectic concentration is not employed as the solidification temperature is not very sensitive to the exact mixing ratio (Large-Scale Solar Thermal Power, Werner Vogel and Henry Kalb, Wiley-VCH Verlag GmbH & Co, KGaA, Weinheim, 2010, page 245. The Hitec XL

mixture is manufactured by dissolving the three salts ($\text{Ca}(\text{NO}_3)_2$, NaNO_3 and KNO_3) in water. It has the disadvantage that, in order to obtain the eutectic melt, this high amount of water (59 weight%) needs to be boiled off, leading a large energy consumption.

5 US 7,588,694 B1 (Bradshaw et al., 2009) describes the use of quaternary compositions comprising nitrate salts of Na, K, Li and Ca. For comparison, an eutectic nitrate salt composition is disclosed containing 21 mol% Na, 49 mol% K, and 30 mol% Ca, having a melting temperature of 133 °C (Table 2). No decomposition temperature is given. Also, for comparison,
10 an eutectic nitrate salt composition is disclosed containing 30 mol% Na, 50 mol% K, and 20 mol% Ca, having a melting temperature of 505 °C (Table 3). No melting temperature is given. The use of lithium nitrate is undesirable due to the high cost thereof.

There is little or no research on higher order mixtures of nitrates.

15 Hence, there is a need for a low-cost nitrate salt based mixture that has both a low melting temperature and a high decomposition temperature, and is easy to make and to handle.

DETAILED DESCRIPTION OF THE INVENTION

20 It is an object of the present invention to provide a nitrate salt composition for use as heat transfer fluid (HTF) and as thermal energy storage fluids which have both a low melting temperature and a high decomposition temperature, as well as to a method for the production thereof, and which are easy to make and to handle.

25 This object is met by the double salt of $\text{Ca}(\text{NO}_3)_2$ and KNO_3 of the present invention according to the independent claim 1.

 The inventors have realized that the use of a double salt comprising $\text{Ca}(\text{NO}_3)_2$ and KNO_3 , hereafter called Ca/K double salt, has unique properties which allows it to be used easily for the manufacture of a
30 nitrate-based heat transfer fluid (HTF), in particular to produce a melt comprising NaNO_3 , KNO_3 and $\text{Ca}(\text{NO}_3)_2$.

According to one embodiment, the Ca/K double salt is a particulate product from a melt, comprising 1.5 to 5.5 weight% of K (present as KNO_3), 70 to 80 weight% of $\text{Ca}(\text{NO}_3)_2$ and 13 to 18 weight% of water.

5 According to another embodiment, the Ca/K double salt is a particulate product from a melt, comprising 2.5 to 4.0 weight% of K (present as KNO_3), 74 to 75 weight% of $\text{Ca}(\text{NO}_3)_2$ and 15 to 16 weight% of water.

According to one embodiment, the double salt of $\text{Ca}(\text{NO}_3)_2$ and KNO_3 is ammonium-free.

10 According to a preferred embodiment, the particulate product is a product marketed under the tradename "NitCal/K" by Yara International, Oslo, Norway. NitCal/K is a Ca/K nitrate with the general formula $\text{KNO}_3 \cdot 5\text{Ca}(\text{NO}_3)_2 \cdot 10\text{H}_2\text{O}$ and having an average chemical composition of about 9 weight% of KNO_3 (about 3.5 weight% of K), about 74 weight% of $\text{Ca}(\text{NO}_3)_2$ and about 16 weight% of water. It can be manufactured as a
15 free-flowing solid particulate product with a low water absorption and caking tendency.

Although the different components may be provided as a combined aqueous solution, such as the Hitec XL solution, or as different aqueous solutions of $\text{Ca}(\text{NO}_3)_2$, KNO_3 and NaNO_3 , the advantage of the
20 present invention is that a melt can be produced based on mixing solid components only, followed by controlled heating, i.e. heating up the solid mixture using a specific temperature program and/or temperature gradient. This process avoids removal of the water from the aqueous solution according to the prior art.

25 According to one embodiment, a melt comprising at least NaNO_3 , KNO_3 and $\text{Ca}(\text{NO}_3)_2$ is produced, comprising mixing NaNO_3 , KNO_3 , and the Ca/K double salt in their particulate form according to the invention, followed by controlled heating and melting of the resulting mixture. The skilled person will understand that several other options are available for mixing
30 and melting the three components, such as mixing two out of three components and adding a third component to the melt.

According to one embodiment, the Ca/K double salt is used to directly produce an HTF (i.e. a melt), in particular to produce an HTF (i.e. a melt) comprising NaNO_3 , KNO_3 and $\text{Ca}(\text{NO}_3)_2$. When the Ca/K double salt used as a source of Ca, this avoids boiling of large amounts of water, as is the case of the Hitex XL product. Within the context of this invention, with “directly” is meant a use which does not involve the production of an intermediate solid product comprising NaNO_3 , KNO_3 and $\text{Ca}(\text{NO}_3)_2$.

According to one embodiment, the melt comprises $\text{Ca}(\text{NO}_3)_2$, NaNO_3 and KNO_3 in a weight ratio of (30 to 50) : (10 to 20) : (30 to 50), provided the sum of the weight of $\text{Ca}(\text{NO}_3)_2$, NaNO_3 and KNO_3 is 100 %.

According to a preferred embodiment, the melt comprises $\text{Ca}(\text{NO}_3)_2$, NaNO_3 and KNO_3 in a weight ratio of about 42:15:43, provided the sum of the weight of $\text{Ca}(\text{NO}_3)_2$, NaNO_3 and KNO_3 is 100 %. The latter ratio is about the eutectic point of the ternary composition and offers the lowest melting point. Hence, it is advantageous to mix the three components in a solid particulate form and melt the resulting particulate mixture, as less energy will be required.

With the composition according to the invention, a melting temperature of about 131 °C is achieved, which is advantageously lower than that achieved using the currently used binary salt (220 C) and is in the range of melting temperatures disclosed in the prior art for this kind of ternary salt.

With the composition according to the invention, a decomposition temperature of 536 °C is achieved, which is surprisingly in the same range, and even higher, than the decomposition temperature of the currently used Solar Salt (525 °C) and higher than the reported decomposition temperature of the HitecXL product (500 °C). Very surprisingly, using the Nitcal/K product as described above in admixture with NaNO_3 and KNO_3 salts of a superior quality (i.e. containing few impurities), the resulting melt having a weight ratio of about 42:15:43 can reach a decomposition temperature of 569 °C (at 3 % weight loss), which is surprisingly high, such that an upper operating temperature of the melt of about 550 to 560 °C is achievable. Using NaNO_3 and KNO_3 salts of a lower quality (i.e. containing more

impurities), a decomposition temperature of 525 °C (at 3.5 % weight loss) is obtained, which corresponds to an upper operating temperature of the melt of about 510 to 530 °C. Without being bound by theory, it is assumed that these high upper operating temperatures are achievable due to the high quality of the Nitcal/K product, i.e. its low level of impurities. Hence, using the Nitcal/K product as described above, in admixture with NaNO₃ and KNO₃ salts of a high quality (i.e. containing few impurities), the resulting melt having a weight ratio of about 42:15:43 has a wide operating temperature of about 131 °C to about 560 °C. A wide temperature range is advantageous as less salt is needed to absorb the same amount of energy.

Furthermore, when using the specific Nitcal/K product for manufacturing the HTF melt, which is chloride-free, the HTF melt is much less corrosive than other existing HTF melts, which means that the lifetime of system components in contact with the HTF melt is extended.

The Ca/K double salt may be produced according to a method disclosed in US Patent 6 610 267 (Norsk Hydro, 2003), which document is enclosed herein by reference. In summary, a melt is produced by mixing a potassium source with a calcium nitrate source and heating the mixture to a temperature of 150 to 155 °C. An aqueous Ca(NO₃)₂ solution is suitable as a calcium nitrate source. Potassium nitrate (KNO₃) in a solid or aqueous form is suitable as a potassium source, but alternatively also KOH, neutralised with nitric acid can be used as a potassium source. Prior to conventional particulation, the water content in the melt is adjusted by evaporation. Furthermore, it was found that undercooling was avoided and that particulation with conventional methods (such as prilling and granulation) was possible when the melt has a certain concentration ratio of K, Ca(NO₃)₂ and water, in particular comprising 1.5 to 5.5 weight% of K (present as KNO₃), 70 to 80 weight% of Ca(NO₃)₂ and 13 to 18 weight% of water. Granulation provided particles with a nice spherical shape, and the crushing strength of 2.8 mm particles was 3 to 5 kg. No caking or post-melt reactions occurred during cooling of the material.

The invention also relates to a method for the manufacture of a melt as disclosed in the application.

According to one embodiment, the invention relates to the manufacture of a nitrate-based heat transfer fluid (HTF), comprising mixing a double salt of $\text{Ca}(\text{NO}_3)_2$ and KNO_3 , and at least NaNO_3 and KNO_3 , followed by controlled heating and melting of the resulting mixture. The melt may be used directly as an HTF or as a thermal energy storage fluid.

According to one embodiment, the invention relates to the manufacture of a nitrate-based melt, preferably to be used as heat transfer fluid (HTF) and/or a thermal storage fluid, comprising mixing a double salt of $\text{Ca}(\text{NO}_3)_2$ and KNO_3 , with NaNO_3 and KNO_3 .

According to another embodiment, the invention relates to the manufacture of a nitrate-based melt, preferably to be used as heat transfer fluid (HTF) and/or a thermal storage fluid, comprising mixing a double salt of $\text{Ca}(\text{NO}_3)_2$ and KNO_3 , with NaNO_3 and KNO_3 , wherein 56 weight% of the double salt of $\text{Ca}(\text{NO}_3)_2$ and KNO_3 , 15 weight% of NaNO_3 and 38 weight% of KNO_3 are mixed, followed by controlled heating and melting of the resulting mixture, such that the resulting melt comprises $\text{Ca}(\text{NO}_3)_2$, NaNO_3 and KNO_3 in a weight ratio of about 42:15:43. Such a method provides a (nearly) eutectic melt having a low melting point and a high decomposition point.

According to a preferred embodiment, the double salt of $\text{Ca}(\text{NO}_3)_2$ and KNO_3 , NaNO_3 and KNO_3 are mixed in a solid particulate form. This has the advantage that said components of the melt may be used on conventional systems which are designed and are being used for the production of the binary Solar Salt, without large investments.

The invention will now be illustrated by an example. Such example should not be construed as limiting the scope of the invention, which is defined by the appended claims.

Description of Figures

Figure 1: Differential Scanning Calorimetric (DSC) diagram of the ternary salt mixture consisting of 42 weight % of $\text{Ca}(\text{NO}_3)_2$, 15 weight% of NaNO_3 and 43 weight% of KNO_3 .

Figure 2: Thermogravimetric analysis (TGA) of the ternary salt melt consisting of 42 weight % of $\text{Ca}(\text{NO}_3)_2$, 15 weight% of NaNO_3 and 43 weight% of KNO_3 .

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EXAMPLES

Example 1:

To obtain an eutectic ternary melt consisting of 42 weight % of $\text{Ca}(\text{NO}_3)_2$, 15 weight% of NaNO_3 and 43 weight% of KNO_3 , 15 weight% of particulate NaNO_3 (technical grade), 38 weight% of particulate KNO_3 (technical grade) and 56 weight% of particulate Nitcal/K (Yara International SA, Oslo) was mixed in a laboratory scale mixer and heated to about 131 °C, at which temperature the melting of the mixture started. All the water was evaporated at a temperature of about 250 °C. The composition of Nitcal/K is 9.2 weight% KNO_3 , 74.5 weight % $\text{Ca}(\text{NO}_3)_2$ and 16.3 weight% of water.

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A DSC diagram of the ternary mixture is shown in Figure 1 showing the melting behaviour of the mixture.

A thermogravimetric analysis (TGA) of the ternary salt melt is shown in Figure 2, in comparison with the commonly used binary melt (Solar Salt). It shows a decomposition temperature of 525 °C at a 3.5 weight loss, compared to a decomposition temperature of 525 °C at a 2.8 weight loss for the binary melt.

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CLAIMS

1. Use of a double salt of $\text{Ca}(\text{NO}_3)_2$ and KNO_3 for the manufacture of a nitrate-based heat transfer fluid (HTF).
- 5 2. Use of a double salt of $\text{Ca}(\text{NO}_3)_2$ and KNO_3 for the manufacture of a nitrate-based thermal energy storage fluid.
3. The use according to any one of claims 1 to 2, wherein the double salt of $\text{Ca}(\text{NO}_3)_2$ and KNO_3 is a particulate product from a melt comprising 1.5 to 5.5 weight% of K (present as KNO_3), 70 to 80 weight% of
10 $\text{Ca}(\text{NO}_3)_2$ and 13 to 18 weight% of water.
4. The use according to any one of claims 1 to 3, wherein the double salt of $\text{Ca}(\text{NO}_3)_2$ and KNO_3 is a particulate product from a melt comprising 2.5 to 4.0 weight% of K (present as KNO_3), 74 to 75 weight% of $\text{Ca}(\text{NO}_3)_2$ and 15 to 16 weight% of water.
- 15 5. The use according to any one of claims 1 to 4, wherein the double salt of $\text{Ca}(\text{NO}_3)_2$ and KNO_3 has the general formula $\text{KNO}_3 \cdot 5\text{Ca}(\text{NO}_3)_2 \cdot 10\text{H}_2\text{O}$ and has an average chemical composition of about 9 weight% of KNO_3 (about 3.5 weight% of K), about 74 weight% of $\text{Ca}(\text{NO}_3)_2$ and about 16 weight% of water.
- 20 6. The use according to any one of claims 1 to 5, wherein the double salt of $\text{Ca}(\text{NO}_3)_2$ and KNO_3 is ammonium-free.
7. The use according to any one of claims 1 to 6, wherein the melt comprises at least NaNO_3 , KNO_3 and $\text{Ca}(\text{NO}_3)_2$.
8. The use according to any one of claims 1 to 7, wherein the melt
25 comprises $\text{Ca}(\text{NO}_3)_2$, NaNO_3 and KNO_3 in a weight ratio of (30 to 50) : (10 to 20) : (30 to 50), provided the sum of the weight of $\text{Ca}(\text{NO}_3)_2$, NaNO_3 and KNO_3 is 100 %.
9. The use according to any one of claims 1 to 8, wherein the melt
30 comprises $\text{Ca}(\text{NO}_3)_2$, NaNO_3 and KNO_3 in a weight ratio of about 42:15:43.

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10. The use according to any one of claims 1 to 9, wherein a melt comprising NaNO_3 , KNO_3 and $\text{Ca}(\text{NO}_3)_2$ is produced, comprising mixing NaNO_3 , KNO_3 and the double salt of KNO_3 and $\text{Ca}(\text{NO}_3)_2$ in particulate form, followed by controlled heating and melting of the resulting mixture.
 11. The use according to any one of claims 1 to 10, wherein the melt has a melting temperature of 131 °C.
 12. The use according to any one of claims 1 to 11, wherein the melt has a decomposition temperature of at least 510 °C, preferably at least 525 °C, more preferably at least 550 °C.
 13. Method for the manufacture of a nitrate-based melt, comprising mixing a double salt of $\text{Ca}(\text{NO}_3)_2$ and KNO_3 , with NaNO_3 and KNO_3 , followed by controlled heating and melting of the resulting mixture.
 14. The method according to claim 13, wherein 56 weight% of a double salt of $\text{Ca}(\text{NO}_3)_2$ and KNO_3 , 15 weight% of NaNO_3 and 38 weight% of KNO_3 are mixed, followed by controlled heating and melting of the resulting mixture, such that the resulting melt comprises $\text{Ca}(\text{NO}_3)_2$, NaNO_3 and KNO_3 in a weight ratio of about 42:15:43.
 15. The method according to any one of claims 13 to 14, wherein the double salt of $\text{Ca}(\text{NO}_3)_2$ and KNO_3 , NaNO_3 and KNO_3 are mixed in a solid particulate form.
 16. Melt, obtainable using a method according to any one of claims 13 to 15.
 17. Melt, comprising $\text{Ca}(\text{NO}_3)_2$, NaNO_3 and KNO_3 in a weight ratio of about 42:15:43 wherein the melt has an operating temperature of about 131 °C to about 560 °C.
 18. The melt according to claim 17, wherein the melt is produced using a double salt of $\text{Ca}(\text{NO}_3)_2$ and KNO_3 which has the general formula $\text{KNO}_3 \cdot 5\text{Ca}(\text{NO}_3)_2 \cdot 10\text{H}_2\text{O}$ and has an average chemical composition of about 9 weight% of KNO_3 (about 3.5 weight% of K), about 74 weight% of $\text{Ca}(\text{NO}_3)_2$ and about 16 weight% of water.

19. The melt according to any one of claims 16 to 18, for use as a heat transfer fluid (HTF) and/or a thermal energy storage fluid.
20. Use according to any one of claims 1 to 12, and melt according to any one of claims 16 to 19 for use in solar energy applications.

Sample: scenario 3

DSC

Instrument: DSC Q20 V24.9 Build 121

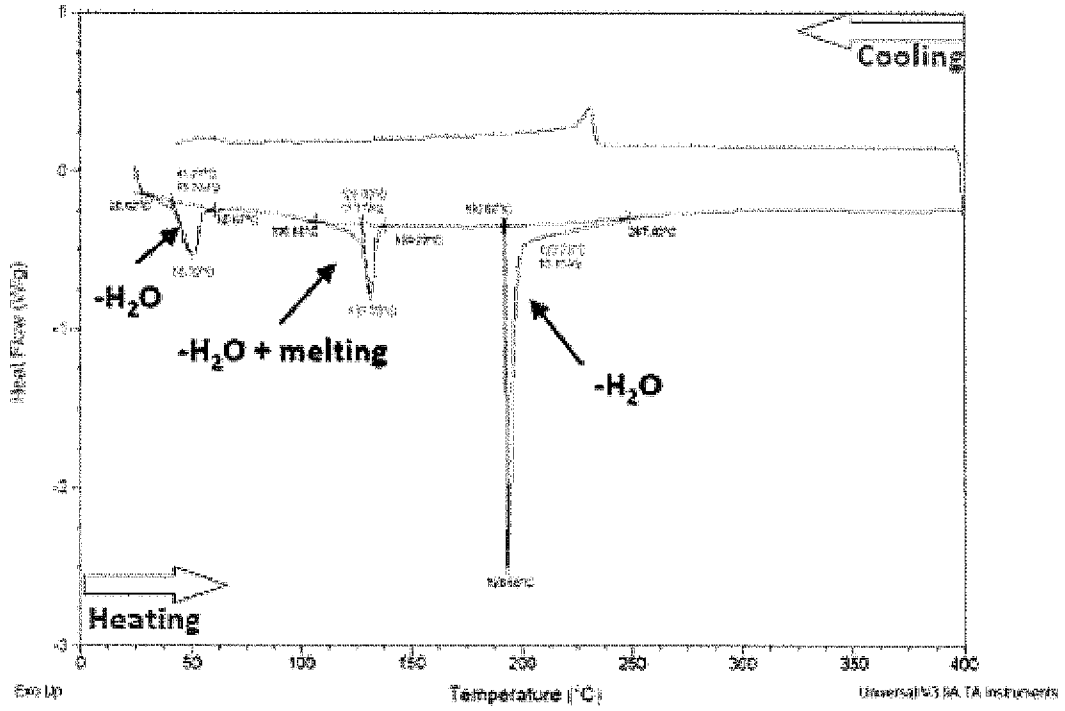
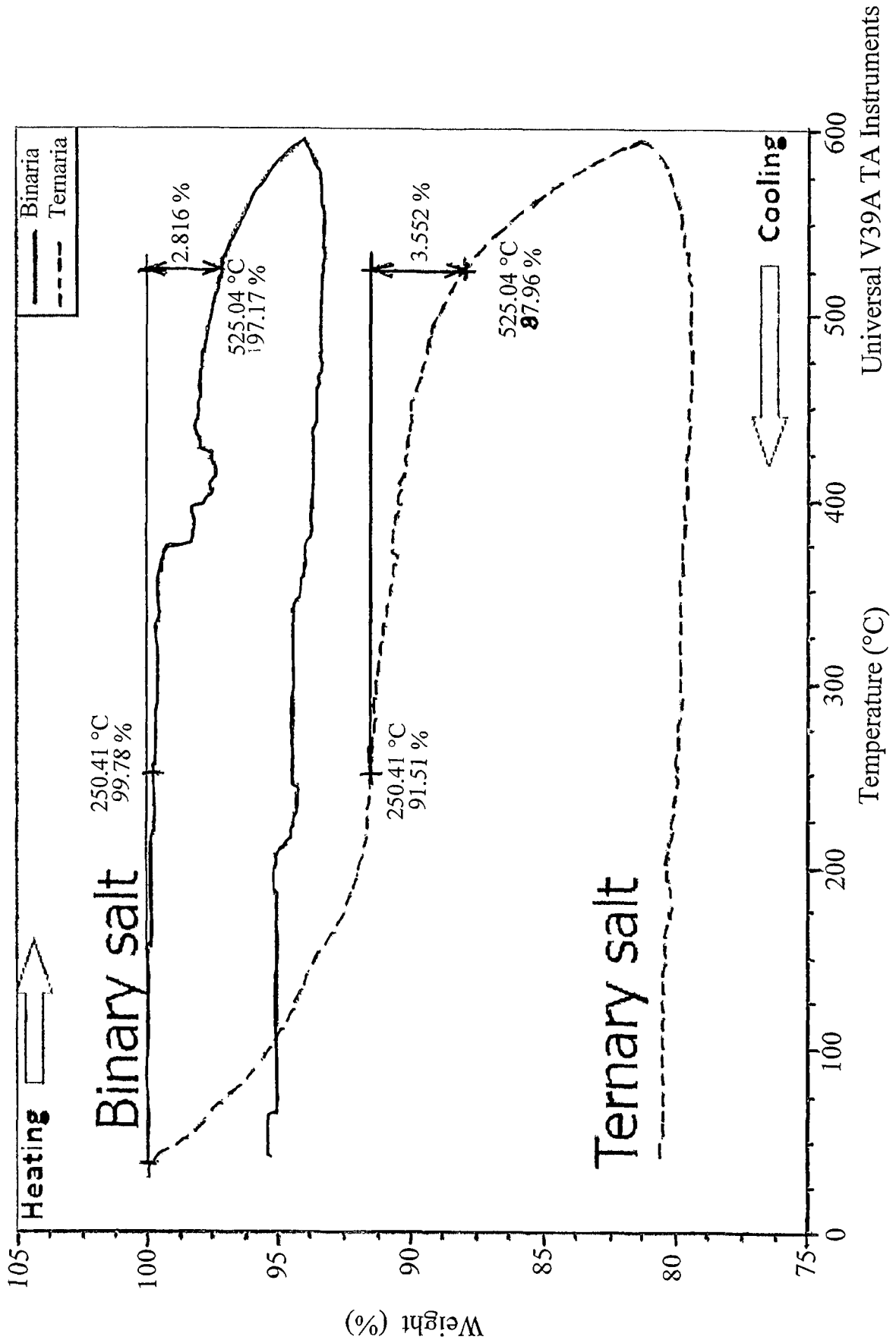


Figure 1



Universal V39A TA Instruments

Figure 2

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2013/069209

A. CLASSIFICATION OF SUBJECT MATTER
INV. C09K5/12
ADD.
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED
Minimum documentation searched (classification system followed by classification symbols)
C09K
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 6 083 418 A (CZARNECKI DAVID JOHN [US] ET AL) 4 July 2000 (2000-07-04) column 1, lines 15-22 column 2, lines 48-57 column 15, line 60 - column 16, line 8 claims 1,8; table 11	1-6
X	BRADSHAW ET AL.: "High-temperature stability of ternary nitrate molten salts for solar thermal energy systems", SOLAR ENERGY MATERIALS, vol. 21, 1990, pages 51-60, XP8132476, cited in the application	16,17, 19,20
Y	page 53, last paragraph - page 56, paragraph first	1,7-12, 18
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Further documents are listed in the continuation of Box C.

See patent family annex.

* Special categories of cited documents :

- "A" document defining the general state of the art which is not considered to be of particular relevance
- "E" earlier application or patent but published on or after the international filing date
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- "P" document published prior to the international filing date but later than the priority date claimed

- "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
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- "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
- "&" document member of the same patent family

Date of the actual completion of the international search 2 December 2013	Date of mailing of the international search report 06/12/2013
Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Authorized officer Puetz, Christine

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2013/069209

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	DE 10 2010 041460 A1 (SIEMENS AG [DE]) 19 January 2012 (2012-01-19)	16,19,20
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